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EXPERIMENTS IN THE USE OF PROGRAMED MATERIALS IN TEACHING AN ELEMENTARY COLLEGE COURSE IN THE BIOLOGICAL SCIENCES. TEACHER EDUCATION RESEARCH SERIES, VOLUME 5, NUMBER 1.

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DESCRIPTORS- *BIOLOGICAL SCIENCES, *PROGRAMED INSTRUCTION, *COLLEGE STUDENTS, GROUP DISCUSSION, LECTURE, EDUCATIONAL EXPERIMENTS, COMPARATIVE ANALYSIS, TEST SCORES, *TEACHING METHODS, PROBLEM SOLVING, *CONVENTIONAL INSTRUCTION,

THE PURPOSES OF THE STUDY WERE TO COMPARE (1) CONVENTIONAL LECTURE, PROGRAM-DISCUSSION, AND PROGRAM-PROBLEM METHODS OF INSTRUCTION, (2) STUDENT PERFORMANCE WITH AND WITHOUT CONFIDENCE IN PROGRAMED INSTRUCTION, AND (3) ACHIEVEMENT ON THE BASIS OF TEST SCORES ON THE FIRST ONE-THIRD OF THE CONVENTIONAL COURSE. TWO EXPERIMENTS WERE CONDUCTED IN INTRODUCTORY COLLEGE BACTERIOLOGY WITH A TOTAL OF 235 STUDENTS DURING 2 TERMS. IN EACH TERM, STUDENTS WERE DIVIDED INTO THREE TREATMENT GROUPS ACCORDING TO METHOD OF INSTRUCTION--(1) CONVENTIONAL, (2) PROGRAM ONLY (FIRST TERM), AND PROGRAM-PROBLEMS (SECOND TERM), AND (3) PROGRAM-DISCUSSION. FINDINGS WERE BASED ON RESULTS OF THREE TESTS GIVEN TO EACH GROUP. ANALYSIS OF COVARIANCE REVEALED NO SIGNIFICANT DIFFERENCES IN PERFORMANCE AMONG TREATMENT GROUPS. THERE WAS GREATER VARIABILITY OF SCORES WITHIN PROGRAM GROUPS THAN WITHIN CONVENTIONAL GROUPS. HIGH ACHIEVEMENT STUDENTS LEARNED BY PROGRAMED INSTRUCTION AS WELL AS STUDENTS OF LOW ACHIEVEMENT. IN THE SECOND TERM, STUDENTS WHO EXPRESSED NO CONFIDENCE IN THE PROGRAM METHOD DID SIGNIFICANTLY BETTER ON TESTS THAN THOSE WHO HAD CONFIDENCE. NO SIGNIFICANT DIFFERENCES EXISTED DURING THE FIRST TERM BETWEEN THE CONFIDENCE AND NO CONFIDENCE GROUPS. IT WAS CONCLUDED THAT PROGRAMED MATERIALS WERE AS EFFECTIVE AS CONVENTIONAL LECTURES IN TEACHING AN INTRODUCTORY COURSE IN BIOLOGICAL SCIENCES TO COLLEGE STUDENTS. (JM)

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Experiments in the Use of Programed Materials in Teaching an Elementary College Course in the Biological Sciences

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Introduction

Considerable research has been done in recent years and is continuing in comparing the relative effectiveness of the use of programed materials to the more traditional teaching methods and materials in public schools and colleges. Numerous studies have shown the programed method to be equal to the traditional lecture-discussion method where quality programs were employed in the experiments.(5) Little research, however, has been done in comparing the effectiveness of learning biological science via programed material accompanied by class discussion and problem exercises as compared to "live" lectures. This study was an attempt in part to fill this gap.

Man has largely passed the era of trial and error in his decision making and problem solving. Today, man has at his disposal a vast reservoir of factual information which is the result of human achievements in many fields. He, however, finds it difficult in some cases to select and apply pertinent information from reliable sources to his individual situations. A student can solve a problem intelligently when he has adequate facts and concepts.(3) He needs precise information in a concise form.

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Factual information is usually given to students in written form such as textbooks or supplementary mimeographed sheets. In many cases, textbooks are an aggregate of facts systematically presented in literary style. One rarely finds a textbook which is both precise and concise, or that has the same outline and emphasizes the same points as the teacher of the course.

The lecture method, to be effective, should be used as a means of provoking students' desire to delve more deeply into subject matter, of stimulating intellectual curiosity, of broadening their viewpoints, and promoting conceptualization of principles and theories. The lecture method should not be used for merely imparting factual information because a good lecturer's time is limited and valuable. Moreover, the opportunity for teacher-student interaction which is highly desirable often is not available. It is generally believed that students can profit most if they have all the necessary basic and factual information about the topic of the lecture before they come to class. When this is the case, the lecturer can most profitably make use of the class time.

Programed material seems to be most appropriate for presenting factual information and basic concepts in a precise and concise form and in a logically sequential manner. As summarized by Green,[1] "A program presents material to students in an organized logical sequence. It requires an overt response by the student to the material of the program, and also provides an immediate feedback to the student regarding the adequacy of this response. As such, it approximates the tutorial teaching situation in that each student participates actively

with respect to the material and receives immediate confirmation or reinforcement for his behavior when it is appropriate."

At present there are two basic types of programs, the straight line or linear program and the branching or intrinsic program. The linear program utilizes a constructed response, that is, the student is required to write an answer or to complete a statement by adding a word or series of words. The branching program requires recognition much as is found in multiple-choice type examination questions. The student chooses one of the alternatives which he thinks is correct. There is little empirical basis at present to favor one general type of program over another.(4) Undoubtedly, different types of programs will eventually prove to be especially useful for particular educational purposes and subject-matter areas. Since the construction of the linear type of program requires less space and time than that of the intrinsic type, the linear program is more economical and widely used.

Several methods of teaching are employed in the field of the biological sciences - lecture, discussion, and laboratory. First-hand experiences such as the field work and laboratory work are essential in the study of natural science.(6) In most cases, two or more of these methods are combined in order to provide students with the most effective learning environment. The common pattern is that which utilizes simultaneously the lecture and laboratory work. The lecture method, traditionally, has been used as a means of imparting factual information.

Experimental evidence indicated that the student's active participation in an educative process is essential to effective learning.[4] He can participate in a learning process in many ways - in an overt or covert manner with physical or mental involvement or both. There should be some means whereby the student can exert himself in the process not only covertly or mentally, but overtly or physically also. In addition to class discussions, the exercise or problem solving method is also made use of in college teaching. In the latter, the student is given questions or problems pertaining to the lesson and is expected to find the correct answers to them with the aid of textbooks and/or reference materials. It is believed that in so doing the student recalls what he has previously learned, organizes and synthesizes the facts, and then applies the knowledge to his immediate situation. In this manner, his memory of the factual information should be enhanced, his ability of conceptualization promoted, and the opportunity of broadening his viewpoint provided.

Objectives of the Study. The purposes of this study were:

1. To compare the effectiveness of three methods of teaching: (a) the conventional lecture method; (b) the program-discussion method; (c) the program-problem method. The last two methods employed programed material as a means of preparation for the class activities in lieu of "live" lectures.
2. To compare the performance on the criterion test of students taught by the program method who had confidence in the teaching method with those without confidence.

3. To compare achievement on the basis of the test scores among the students who were taught by the various methods when classified in terms of their test scores on the examination for the first one-third of the course.

The Experiments

The Department of Agricultural Education conducted two experiments in the use of programed materials in lieu of attending "live" lectures in teaching an introductory course in bacteriology to college students during the 1962-63 school year. The experiment involved programing seven of the eighteen lectures of the course during the Fall of 1962. The seven lectures were those normally given during the middle one-third of the course.

Procedure. One hundred twenty-six students who were enrolled in the course, Bacteriology 6, during the Winter Term of 1963, were randomly assigned to three groups - Groups IA, IIA, and IIIA - of approximately forty-two students each. In Group IA, the students were asked to avail themselves of a normal study pattern - attending the lectures given by the course instructor and studying the prescribed textbook as well as their lecture notes. Students in Groups IIA and IIIA did not attend the lecture classes but were requested to study the programed materials during class time. Group IIIA devoted about twenty-five minutes toward the end of the period to a discussion with an instructor in charge of the group. Students in the program groups were not allowed to take

the programed materials from the classrooms. Review sessions at night were arranged for the students in the latter groups to study the programed materials, if they so desired. The time spent by the students in studying the programed materials was recorded. Students in all three groups had access to the text-book and attended the laboratory classes in the usual manner.

The experiment which lasted four weeks began in the fourth week of the term immediately after the first examination given to measure the students' knowledge taught during the first three weeks. The regular 75-minute class sessions were held two days a week. At the end of the experiment, the second examination or the post test prepared by the course instructor was administered to the students in all groups. The questions in the test were of the objective type, of which fifty per cent were multiple-choice items, and fifty per cent were matching items.

During the Spring Term another experiment was conducted with students who enrolled for the Bacteriology 6 course similar to the Winter Term experiment except with different uses of the programed materials. In this study, one hundred and nine students were randomly assigned to three groups - Groups IB, IIB, and IIIB. Group IB followed the same procedure as did Group IA of the Winter Term. Groups IIB and IIIB students did not attend the lecture classes. Unlike Groups IIA and IIIA, Groups IIB and IIIB were requested to study the programed materials before coming to class.

During class time Group IIB students were assigned problems constructed from the content emphasized by the course instructor in his lectures. The students were allowed to consult each other, the textbook and the programed materials while they were working on the assignment. For Group IIIB, the entire class period was devoted to discussion of the assigned lesson, conducted by a graduate student who was chosen by the course instructor. Students in all three groups, as in the case of the Winter Term experiment, had access to the textbook and attended the laboratory classes in the usual manner.

The schedule of classes and length of the class periods as well as the duration of the experiment of the Spring Term study were the same as in the Winter Term. The tests used in the two experiments were different ones. The second examination on a post test was of the objective type, of which one-third were multiple-choice items, one-third were matching items, and the remaining one-third were problem-solving questions. As in the Winter Term experiment both tests were constructed by the course instructor.

The study patterns and treatments of each of the groups in the two experiments may be summarized as follows:

WINTER TERM EXPERIMENT

Group	Method	Activity and Study Pattern
IA	Conventional	Attended lectures and studied the textbook
IIA	Program Only	Attended no lectures, studied the textbook, and studied the programed materials in class
IIIA	Program-Discussion	Attended no lectures, studied the textbook, studied the programed materials in class, and participated in a short discussion

SPRING TERM EXPERIMENT

Group	Method	Activity and Study Pattern
IB	Conventional	Same as IA
IIB	Program-Problems	Similar to IIA, except studied the programed materials at home and worked on assignments in class
IIIB	Program-Discussion	Similar to IIIA, except studied the programed materials at home and participated in discussion in class

The Program. The programed materials consisted of seven chapters or lectures which were prepared by the writer assisted by the course instructor. Each chapter dealt with a separate topic comparable to one lecture. The titles of the program chapters and the number of frames in each were as follows:

The Program Chapters, Titles, and Number of Frames Employed in the Experiment

Chapter	Title	No. of Frames
I	Antibiotics	108
II	Microbiology of Water	141
III	Microbiology of Milk	119
IV	Microbiology of Soil-Sewage	136
V	Mycology and Industrial Microbiology	75
VI	Milk Products	138
VII	Food Spoilage	90
	TOTAL	807

A characteristic of a program is its density. Density is the ratio of the number of different answers required of the student to the total number of answers required. The density function is an indirect measure of the rate at which information is introduced, and an independent measure of the difficulty level of a program. The number of responses required by the program chapters, the density of each set, and the average time spent by the students for completion appear below.

Characteristics of Program Including Number of Responses, Density, and Time for Students to Complete

Program Chapter	Number of Responses	Density	Average Time in Minutes for Student Completion
I	105	.63	33
II	136	.65	55
III	130	.64	40
IV	128	.70	50
V	82	.77	30
VI	134	.63	55
VII	88	.68	40

A prepared time sheet was used in both experiments to record the amount of time the students spent in study, whether it was done with the aid of the program and/or the textbook or whether it was done in the conventional manner outside of class. An attitude questionnaire designed to elicit the students' attitude and opinions regarding the methods of teaching was administered a few weeks after the experiment.

Results. Shown in Table I are the mean scores of the three groups of each experiment on the various tests. For each test the data are classified for each treatment group - Groups IA, IIA, IIIA, IB, IIB, IIIB. Under each test, the statistics - n (number of students), $\bar{X}$ (mean scores), and SD (standard deviation of the test scores) are given.

TABLE I. THE MEANS AND STANDARD DEVIATIONS OF THE PERFORMANCES ON THE VARIOUS TESTS IN PER CENT FOR BOTH EXPERIMENTS

	1st Examination			Pretest			2nd Examination		
Group	n	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD
				WINTER TERM EXPERIMENT					
IA	43	84.0	9.0	43	23.9	7.8	43	81.1	10.3
IIA	41	86.6	8.7	41	23.3	8.4	41	79.7	10.4
IIIA	42	82.4	9.8	42	22.8	8.8	42	80.6	10.8
				SPRING TERM EXPERIMENT					
IB	37	76.2	7.6	37	29.8	5.4	37	60.4	9.8
IIB	36	76.0	7.6	36	29.4	9.1	36	60.6	10.5
IIIB	36	76.1	7.2	36	28.5	7.9	36	60.0	7.3

It may be observed that the mean scores of the three groups on each of the various tests in each experiment were relatively the same and that the (SD's) of the test scores of the treatment groups on each of the tests were also very much the same except for the pretest in the Spring Term experiment. By Bartlett's test the variances on all the tests in both experiments were found homogeneous except for the pretest in the Spring Term experiment.

As presented below the coefficients of reliability of these measures appear to be sufficiently high for experimental purposes.

Coefficients of Reliability * of the Tests in Both Experiments

Measure	Winter Term	Spring Term
1st Examination	0.92	0.81
Pretest	0.89	0.79
2nd Examination	0.95	0.73

* The coefficients were determined by Kuder-Richardson formula 21.

The validity of the criterion tests used in both experiments was determined by content and predictive approaches. The content validity was assessed subjectively by the course instructor who constructed the tests. The predictive validity was determined by correlating the scores on the criterion tests with the final grade of the course which included the students' performance on the various tests given throughout the term and in their laboratory work. The predictive values of the second examinations for the Winter Term and Spring Term experiments were 0.79 and 0.73 respectively.

By analysis-of-covariance tests of the mean scores on the second examinations of both Winter and Spring Term experiments, using the first examination scores as the adjusting variable, the differences in the mean scores of the various groups were not significant at the five per cent level.

In an attempt to determine whether the students having confidence in the program methods (Groups II and III) would do better than those lacking confidence in terms of their criterion performance the test scores of the two attitude groups on the second examination were compared.

TABLE 2. MEAN SCORES OF THE CONFIDENCE AND NONCONFIDENCE GROUPS, WITH THE TWO TREATMENTS COMBINED FOR BOTH EXPERIMENTS

		Mean Scores in Per Cent		
			2nd Examination	
Attitude Group	n	1st Exam.	Actual	Adjusted
WINTER TERM				
Confidence	37	84.0	80.1	80.6
Nonconfidence	39	85.4	80.2	80.0
SPRING TERM				
Confidence	43	77.1	58.7	58.2
Nonconfidence	19	75.0	61.3	62.6

By analysis of covariance the difference in the adjusted scores between the confidence and nonconfidence groups was not significant in the Winter Term experiment, but significant in the Spring Term experiment at the five percent level.

In determining the differences in performance on the criterion measures among the students taught by the various methods, with different levels of test scores on the first examination given prior to the experiment, analysis of covariance was employed in both experiments. Table 3 presents some statistics which describe the performance of the groups, categorized according to the first examination scores and treatments on the criterion tests.

TABLE 3. POST TEST MEAN SCORES OF STUDENTS CLASSIFIED IN TERMS OF THE FIRST EXAMINATION SCORES FOR BOTH EXPERIMENTS

WINTER TERM EXPERIMENT

Treatment	Number of Students	Adjusted Mean
LOWEST THIRD		
Conventional	14	78.22
Program Alone	13	77.70
Program-Discussion	14	79.00
MIDDLE THIRD		
Conventional	14	83.15
Program Alone	13	79.10
Program-Discussion	14	78.66
HIGHEST THIRD		
Conventional	15	82.66
Program Alone	15	81.84
Program-Discussion	14	85.76

SPRING TERM EXPERIMENT

Treatment	Number of Students	Adjusted Mean
LOWEST THIRD		
Conventional	12	55.6
Program-Problem	10	55.5
Program-Discussion	11	58.1
MIDDLE THIRD		
Conventional	14	61.8
Program-Problem	13	60.5
Program-Discussion	13	60.1
HIGHEST THIRD		
Conventional	11	63.9
Program-Problem	13	64.9
Program-Discussion	12	61.6

As determined by analysis of covariance no significant differences were found among the methods within each of the levels of achievements in the first one-third of the course.

Discussion

The effectiveness of the programed materials as a teaching device is demonstrated primarily by comparing the post test scores of students in the program groups with the conventional lecture group. Since the students were randomly assigned to the various groups, possible initial biases were theoretically controlled. As determined by the analyses of covariance no significant differences among the three treatment groups in their performance on the criterion measures were found at the five per cent level.

In comparison with the mean scores of the first examination in the Spring Term experiment, the mean scores on the second examination for all three treatment groups were found to be relatively low (76% vs. 60%). There is little doubt the second examination was more difficult than the first examination. Nevertheless, it was obvious that the test did not favor any particular group in the experiment.

Quite contrary to the results of many previous studies, the variability of the test scores made by the students taught by the program in both experiments was found to be greater than that by the conventional method. However, this could be accounted for by the difficulty of the post tests themselves, and also by the combination of the various practices introduced in the programed instruction methods. No conclusive statement, therefore, can be made from the data that the effect in the increase in variability was due to the methods of teaching.

It is generally believed that students learn more effectively if they have confidence in the teacher, in the method of teaching, and in the teaching material. The information obtained from the attitude questionnaire answered by the students after the experiment, indicated that approximately 50 per cent of them in the Winter Term experiment and 30 per cent in the Spring Term experiment had no confidence in the program and the methods used in Groups II and III. No significant differences in terms of the post test scores existed between the two groups i.e., those expressing confidence and those no confidence in the Winter Term experiment. In the Spring Term experiment, however, the students who expressed no confidence in the programed method to which they were exposed did significantly better than those who had confidence in the criterion test.

The data in Table 3 show the consistency of the two experiments in the performance of the students within each of the different levels of prior achievement on the first examination. The students taught by the three methods did equally well on the criterion tests. High achievement students learned by programed instruction as well as students of low achievement.

An attempt was made to determine an efficiency index as a means of comparing the effectiveness of the three methods on the basis of the test scores and the amount of time spent in study. The students' records of time were found to be unreliable. The majority of the students did not keep records of the time as closely as was requested. From the available data, it is possible that

Groups IIB and IIIB spent more time during the experiment than did Group IB since the students in the former were asked to work on the programed materials with the accompanying answer sheets and read the textbook before coming to each class whereas the students in the latter were not. It might appear that the conventional group was more efficient than the other two groups that used the programed materials on the basis of the post test scores.

No attempt was made to determine whether the program groups retained the knowledge of the subject matter for a longer period of time than did the conventional group. Because the program groups spent more time studying the course materials and were more systematic in their learning activities than were the lecture groups, it would have been difficult to have measured relative retention value of the teaching methods alone. Neither was it possible to determine whether one group could better utilize the information or the acquired knowledge than another.

An experiment for effectiveness of any method of instruction should not be considered complete unless all questions regarding retention, utilization or application of the knowledge learned have been satisfactorily answered through a series of developmental or longitudinal studies.

An experiment on teaching methods has inherent difficulties due to the presence of numerous interacting variables. Many of these variables cannot be controlled without disturbing the routine academic activities especially when

college students are used as the subjects. Little can be done to control the many variables which are characteristic of the learning process such as motivation, interest, anxiety and fear of unfair treatments, competition, and the teacher's attitude toward the experiment.

In an experiment on instructional methods, the so-called Hawthorne effect may be present. It was evident from the responses in the questionnaire that the students in Groups II and III feared they would not receive the same information as their classmates in the lecture group. Since the students knew the examination would be prepared entirely by the instructor of the lecture group, their fear seemed natural.

The programed material was constructed with the assistance of the instructor of the course and her assistant for the first experiment which was conducted in the Winter Term 1963. In the Spring Term 1963, a new instructor and a different graduate assistant helped conduct the second phase of the study.

Factors involved with the discussion Groups IIIA and IIIB deserve mention since they undoubtedly affected the performance of the students. The discussion classes were conducted by graduate assistants. Their personality, competency in the subject matter, teaching ability, and discussion techniques employed were some of the factors which could have influenced the effectiveness of the teaching method used in these groups.

The students' behavior outside the classroom could not be controlled. The students were requested to study the program at their leisure before coming to class, thus they were on their own. Whether full use was made of the program by the students is another factor which is difficult to determine. The students could turn in their answer sheets all filled out with the correct responses without having really read the program. If this were the case and the students failed to do their best because they cheated, one cannot accurately predict the ultimate potential effectiveness of the programed material.

It should be further noted that in this study the students in all treatments had much in common. They received the same laboratory instruction and studied the same prescribed textbook. Though these activities were not a part of the experimental treatments their effects on student performance on the criterion measures could be substantial and thus deserve mention. The students spent at least one half of their class time ordinarily scheduled for the course attending the laboratory sessions. It could be expected that much of the course instruction which the students were presumed to have learned during the experimental period could be obtained from both the laboratory work and textbook reading. Providing the students with the same laboratory instruction and prescribed textbook reading to all treatments might have reduced the possibilities of obtaining significant difference between the treatments.

Conclusions and Implications

The nonsignificant-difference results of the main comparison in the Winter Term experiment indicate that the programed materials developed were as effective as the conventional lectures in teaching an introductory course in the biological sciences to college students.

In the light of the present study it may be inferred that in a biological science course in which students are taught by laboratory work and with the use of a textbook either the programed instruction using the programed materials alone or in combination with discussion or with problem assignments can be employed as effectively as the conventional lecture method. A programed instruction method may be conducted by a graduate assistant. In the case where only the programed materials are used exclusively, supervision by an experienced instructor is not needed. Students, however, should have an opportunity to consult the instructor in charge of the course if they so desire.

Whether or not a student has confidence in a method of programed instruction does not adversely affect his performance in the course as long as he closely follows the directions in the instruction, satisfactorily fulfills other requirements of the course, and is sufficiently motivated to do his best. In fact, as demonstrated in one of the experiments in this study, the students who expressed no confidence in the programed methods to which they were exposed did significantly better than the others on the criterion test.

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